A COST-EFFECTIVE AMPLIFIER FOR ELECTROMAGNETIC FIELD STRENGTH MEASUREMENT

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Abstract-**Problems associated with high sensitivity electromagnetic radiation measurements arise when low levels of broadband radiated emissions are to be detected. Such measurements require expensive and sensitive equipment operating in a broad range of frequencies. This paper presents an inexpensive broadband amplifier designed to increase the overall gain of a measurement system consisting of a 50 ohm broadband antenna coupled to a 50 ohm input spectrum analyzer. Addition of the amplifier increases system gain by nearly 30 dB with insignificant degradation in the signal-to-noise ratio. The bandwidth of the system exceeds 1000 MHz, with the frequency ranging between 30MHz and 2.2GHz**.

I. INTRODUCTION

In biomedical measurements, low-level electromagnetic fields must often be evaluated to determine the delicate effect of radio frequency radiation on living cells [1,2,3]. General-purpose equipment, accessible in most laboratories, is designed to measure larger field strengths than those which are frequently important for biological applications. However, sensitivity can be greatly improved by the introduction of an amplifier whose parameters are adjusted to match the desired gain and bandwidth. The availability of new, wide-band integrated circuits, such as the RF2310 from RF Micro Devices, Inc., makes it possible to design inexpensive amplifiers suitable for performing the desired functions [4,5].

The following text shows the results of the design process, along with measurements from an experimental test system that includes the receiving antenna, the spectrum analyzer, and the designed amplifier, which is inserted between the antenna and the analyzer to increase sensitivity of the system (Fig. 1). The amplifier operates within the band of frequencies between 15 MHz and 2000MHz with a total gain of about 30 dB after two stages. The total cost of the system was less than $150.

The amplifier system is based on the RF2310 high linearity integrated circuit. The circuit requires a small number of external, high frequency components. Additionally, a printed circuit board with minimal losses and maximum signal integrity was designed to minimize high frequency reflections (input and output SWR are less than 1.5). The maximum input power to the amplifier system is 10dBm. The small signal gain of the single integrated circuit stage is about 15 dB. Two single stages were cascaded to increase the gain.

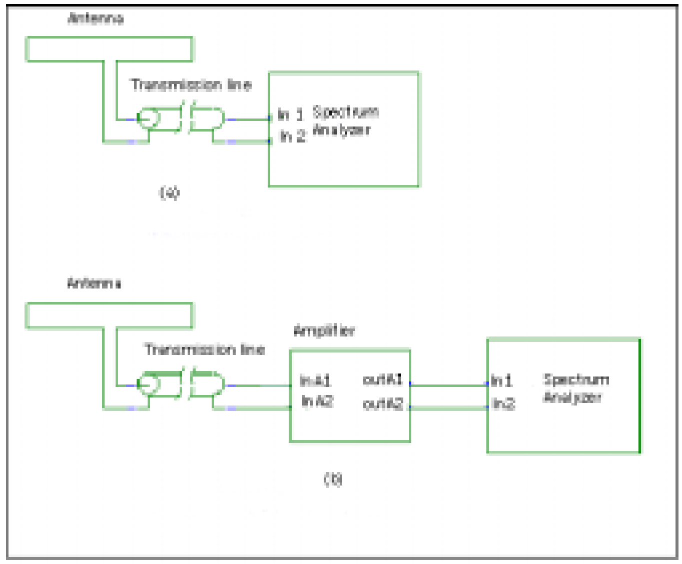

Fig. 1: Application of the amplifier in the test system. The upper figure shows the system without the amplifier, while the lower figure shows the enhanced system with the amplifier inserted between the antenna feeder and the spectrum analyzer.

II. THE AMPLIFIER SYSTEM AND CIRCUIT CHARACTERISTICS

Fig. 2 illustrates the basic structure of the amplifier system. It consists of two stages, symbolized by the transistors, that are connected by means of a coupling network (output network 1). The boxes labeled “input network” and “output network 2” serve as coupling circuits between the first stage and the source and between the output stage and the load respectively.

The diagram of a single stage of the amplifier is shown in Fig. 3. The integrated circuit is represented by the triangle, all other components are embedded within the amplifier printed board topology and connected to corresponding terminals to form the coupling and supply network (Fig. 4). Before construction, the single stage amplifier design was simulated using the high frequency software program “Serenade,” from Ansoft Corporation. Results are shown in Fig. 5.

The chip used in simulations was an improved version of RF2310—the RS2312. Therefore, the simulations show less noise than the actual circuit, which had a noise figure of 6dB. The experimentally measured frequency response of the single stage of the amplifier is shown in Fig. 6, while the experimentally measured frequency response of the two-stage amplifier is shown in Fig. 7.

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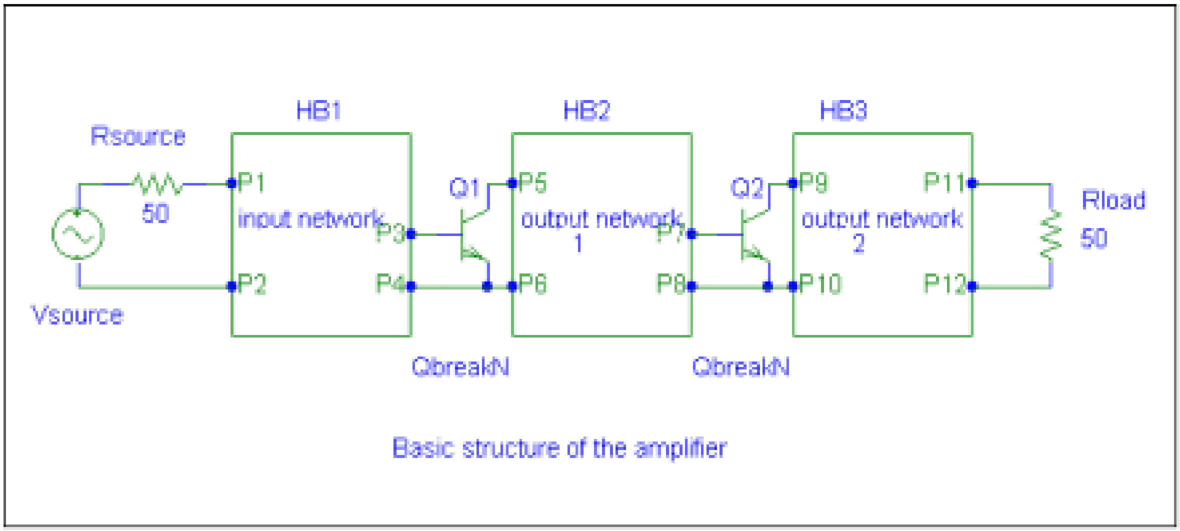

Fig. 2: Typical structure of the amplifier. Two stages, symbolized by the transistors, are connected by means of the coupling network (output network 1). “Input network” along with “output network 2” serve as coupling circuits between the first stage and the source and between the output stage and the load respectively.

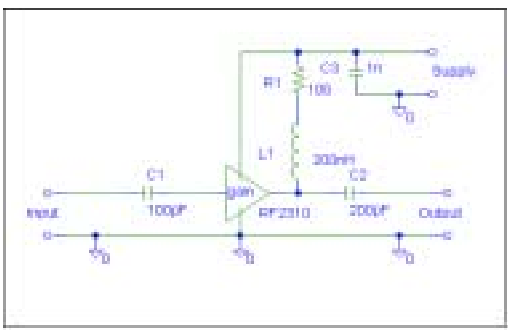

Fig. 3: Typical connection of the RF2310.

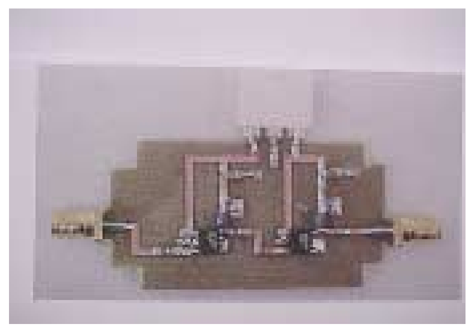

Fig. 4: Photograph of the top view of the final printed circuit board with all components connected before packaging the integrated circuit

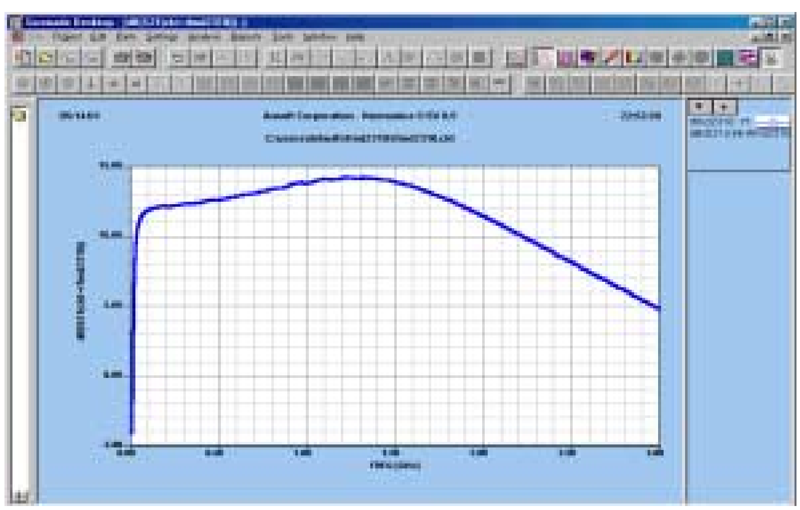

Fig. 5: Simulated frequency response of the single stage of the amplifier.

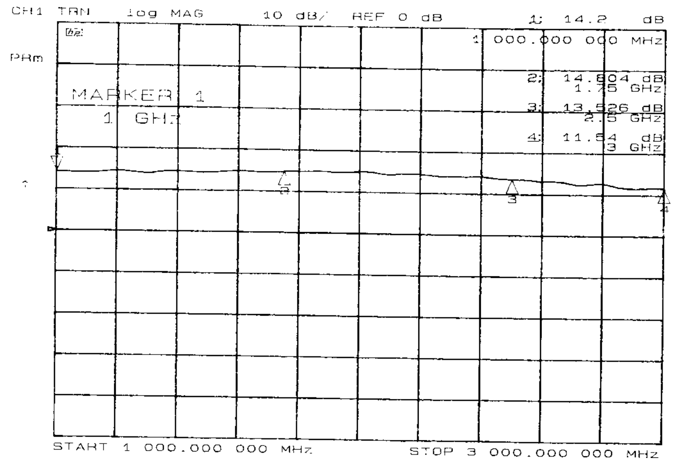

Fig. 6: Experimentally measured frequency response of the single stage of the amplifier.

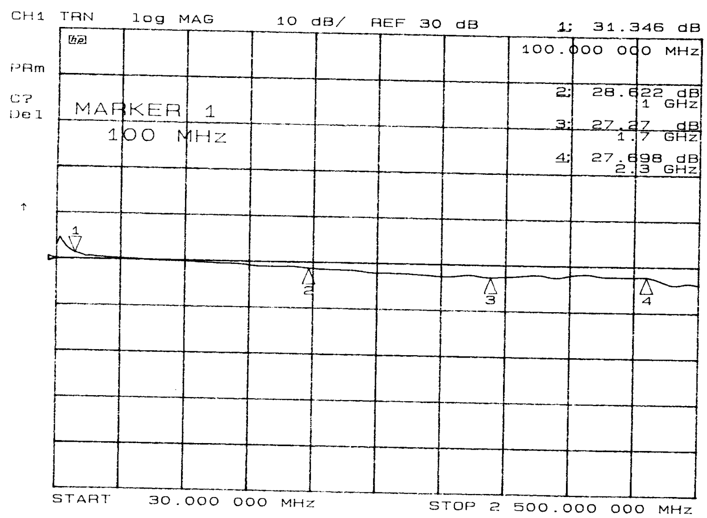

Fig. 7: Frequency response of the two-stage amplifier

III. Conclusion

The availability of new, wide-band integrated circuits, such as the RF2310 from RF Micro Devices, Inc., makes it possible to design inexpensive amplifiers suitable for many different applications in bioengineering-related measurements. Modern circuit analysis and CAD tools allow for the straightforward development of inexpensive laboratory equipment using a step-by-step design approach.

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